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ABSTRACT

This essay, the concluding section of a larger study, examines the present state of cognitive science and instructional theory as reflected in the study's earlier chapters. Cognitive analyses of tasks are reported in the broad domain of language comprehension and production (e.g., understanding, composing, and answering questions about texts). The following are examined as statements of a theory of expertise in language processing: (1) processes in diverse tasks; (2) the role of prior knowledge; and (3) the role of strategies. From this examination, goals and objectives of instruction in the domain of text processing are described. Learning as coherence building, learning as schema instantiation and schema construction, and acquiring processing skill are discussed as contributing to a theory of cognitive acquisition. The effects of instructional interventions in reading and writing are explored. The foregoing provides the basis for examining the implications of emerging theories of expertise and acquisition for instructional prescriptions. (PN)

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COMPREHENDING AND LEARNING: IMPLICATIONS FOR A COGNITIVE THEORY OF INSTRUCTION

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Comprehending and Learning: Implications for a Cognitive Theory of Instruction

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The task in this concluding section is to consider the implications of the present chapters for instruction. Let us begin by considering what is meant by the word "instruction." The chapters in this book press us toward a definition that is different from the one that has guided scientific thinking about education for many decades. Together they stress a theme that has become central in cognitive science: People *construct* rather than receive knowledge. Knowing something, whether a body of interrelated concepts or a performance skill, is a result of mental activity by an individual. This activity uses external information, and is thus responsive to what an individual may be told or shown. But the person does not simply "store" this information as received. Instead the person transforms it, links it to knowledge already held, and uses it to build a coherent interpretation of the world and its events. If knowledge is constructed rather than recorded as received, it does not make sense to think of instruction as directly conveying knowledge or skill. Rather, we must think of instruction as setting in motion learners' natural processes of knowledge construction and providing external information that is likely to be used productively.

If instruction is a matter of activating and nourishing processes of knowledge construction, then to arrive at a prescription for instruction it is important to know what these processes of knowledge construction are. This means that we cannot construct a scientific theory of instruction by passing directly from statements of knowledge or skill objectives to prescriptions for intervention. We are forced, instead, to seek a theory of instruction that has three major elements: (1) a theory of expertise that describes the kind of skilled performance or elaborated knowledge structure we hope to evoke in the learner; (2) a theory of acquisition that describes the processes of knowledge and skill construction that people use

in the course of acquiring a new competence; and (3) a theory of intervention that prescribes the actions to be taken by an instructor in order to activate the learner's acquisition processes and to provide appropriate external information.

Up to now, cognitive psychology has concerned itself almost exclusively with the first of these three components. For much of its history, cognitive psychologists have been engaged in what may be termed "cognitive task analysis." In this work, the fundamental concern is to describe the mental processes that are involved in performing various kinds of tasks during a given state of competence. Although younger and older people, or novices and experts in a domain, are occasionally contrasted, transitions between states of competence are largely ignored. As a result, we do not presently have a well-developed theory of acquisition, although there has been considerable progress made in describing the nature of cognitive processes used on a variety of complex tasks. In instructional terms, we have moved forward on the agenda of building a theory of expertise in various domains relevant to instruction, but we have not as yet begun to build the theory of acquisition that is needed for a cognitive theory of instruction.

The chapters in this volume reflect the just described state of cognitive science and instructional theory. Most of the chapters report cognitive analyses of tasks in the broad domain of language comprehension and production (e.g., understanding, composing, and answering questions about texts). In the first section of this chapter, I examine each contribution as a statement of a theory of expertise in language processing. From this examination, I attempt to draw an enriched description of goals and objectives of instruction in the domain of text processing. It is also possible to treat several chapters as contributing to an emerging theory of cognitive acquisition. That is what I do in the second section of this chapter. Finally, a few chapters directly explore the effects of instructional interventions in reading or writing. These provide a basis for examining the implications of emerging theories of expertise and acquisition for instructional prescriptions. I discuss these in the third section of the chapter.

THE NATURE OF EXPERTISE IN TEXT PROCESSING

Common Processes in Diverse Tasks

Taken together, the chapters in this volume highlight the fact that skilled language comprehenders seem to call upon very similar processes regardless of the particular task in which they are engaged. Whereas most of the chapters focus on written text comprehension, some are on question answering or on composing texts. In addition, several different kinds of text processing tasks are studied, and a variety of different kinds of texts are the object of attention. Despite this variety, a striking impression emerges that similar processes are involved.

Lehnert, Robertson, and Black are explicit about this. Their account of question answering makes it clear that in order to even interpret a question, people attempt to relate it to prior knowledge of the context to which the question refers. This prior knowledge may have been gleaned from immediately preceding reading or conversation, or it may exist in the form of general schemata that are used to interpret specific events. In either case, the kinds of knowledge called upon and the kinds of processes involved in using it are much like those described in the formal text comprehension models of Just and Carpenter as well as in the story comprehension theories outlined by Voss and by Stein and Policastro, and in the structure seeking theories of expert text processing developed by Meyer and by Scardamalia and Bereiter. What is more, Brown, Palincsar, and Armbruster suggest that the skilled comprehender of a text is one who is able to pose appropriate questions about it. And it is processes of accessing and coordinating knowledge so as to produce text that is coherent at several levels of analysis that create the information processing demand in text composition that is the subject of Bereiter and Scardamalia's chapter. Given all of these commonalities, it seems more fruitful to try to understand the various kinds of language comprehension and production observed as variations built out of a set of common processes and knowledge than as separate and independent capabilities.

The Role of Prior Knowledge

A central theme in many of the analyses presented is the pervasive and powerful role of prior knowledge in text comprehension and text production. For reading, for answering questions, and for composing texts, schemata are activated and then "instantiated" in accordance with the specific situation represented by the text. In each case, the relevant schemata are presumed to be already available for activation. Lack of appropriate schemata, or failure for some reason to access relevant schemata, is a source of difficulty and even a direct cause of failure to understand or to produce sensible text.

Three broad classes of prior knowledge are explored in the papers in this volume. The first is domain-specific knowledge—that is, knowledge about the topic discussed in the text. Voss and Schnotz each develop examples of the ways in which differences in the amount of domain-specific prior knowledge affect the ways in which the text is processed and understood. Lehnert, Robertson, and Black show how such knowledge may be used in answering questions. In the Just and Carpenter model, a process of schema instantiation involving domain specific knowledge is necessary for building a coherent representation of a text's topic.

The second class of knowledge is general world knowledge—that is, knowledge of social relationships and causal structures that are common to many specific situations and domains. The role of knowledge about physical and psychological causality in comprehension is a central theme of Trabasso, Secco, and van den Broek's chapter, and the role of knowledge about goals, plans,

actions, and outcomes as well as personal and social conflict concerns Stein and Policastro and Voss.

The third class is knowledge of rhetorical structures that constrain the form of written communication. Structural knowledge of this kind is a central theme in Stein and Policastro's chapter on the story concept. Scardamalia and Bereiter discuss how rhetorical structure knowledge may help children develop a more sophisticated strategy for interacting with texts. Meyer suggests that knowledge of conventions for organizing and signalling the organization of texts may be part of what distinguishes expert from less-skilled adult readers.

A question raised by several authors is the extent and nature of the interaction between general world knowledge and knowledge of rhetorical structures, especially stories. Trabasso, Secco, and van den Broek find that events are important and are recalled for two reasons: (1) they lie on a causal chain and therefore have several causal connections, and (2) they serve functions as categorized content. Both of these aspects were contained in the original formulations of story grammars. Stein and Policastro's discussion of the many competing definitions of stories, and their distinction between minimally acceptable stories and "non-stories," suggest that certain kinds of world knowledge are systematically embedded in the story structure, which serves as a "guide" to readers and listeners to search a text for particular kinds of social relationships.

Some suggestions for instructional objectives in reading and writing skills emerge from these analyses of the role of prior knowledge in text understanding. First, improvement in reading skill probably depends to a large degree on enlargement of domain-specific and general world knowledge. We need to think of reading instruction as including, or as being closely linked to, instruction in specific domains of knowledge rather than as a separate and largely content-free "skill." If a learner is helped to build an appropriate body of knowledge in some domain, he or she is also helped to become a more skilled reader. The objectives of reading instruction are thus broadened to include specific knowledge about the domains in which people are likely to read. Even more instructional power is likely to accrue from efforts to teach general world knowledge, such as causal inferences and social-personal relationships and expectations. Such knowledge may provide a useful interpretive structure in a wide range of situations.

A second suggestion is that rhetorical structural knowledge itself become an objective of instruction. This suggestion is explicit in several chapters. Stein and Policastro, for example, suggest that both children and teachers would benefit from more explicit knowledge of good story content and structures. Scardamalia and Bereiter suggest that their greater mastery of story schemata, as opposed to other rhetorical structures, makes it easier for children to write stories than other types of texts. Bereiter and Scardamalia's analysis implies that well-established knowledge of various rhetorical conventions and formats helps in reducing the processing demands of composing and inducing more sophisticated texts. Meyer's contrast of adults with different levels of reading skill suggests that one

way of helping people become expert would be to help them acquire knowledge about how various conventional rhetorical markers signal the structure of textual arguments.

In suggesting that certain common rhetorical forms become the direct objects of instruction, it is important to note that we are reviving an older instructional agenda rather than proposing a completely new one. Rhetoric was, after all, a standard part of the school curriculum not very long ago, and remains a part—although not occupying a privileged place—in some countries today. This means that many useful instructional models probably already exist, and that we will do well, as we adopt this new set of objectives, not to overlook the analytic and instructional efforts of the past.

The Role of Strategies

We turn now to the processes involved in using and coordinating prior knowledge with information in the text. Two classes of processes have been discussed in certain chapters. The first class involves processes in skilled reading that occur automatically and without conscious awareness. These are the processes of inference and linkage construction that are at the heart of building a coherent representation of a text. Examples of such constructions are found in Just and Carpenter, Stein and Policastro, and Trabasso, Secco, and van den Broek. Just and Carpenter's model involves a concatenation of local interpretation processes that are largely automatic and may not be open to direct inspection in humans. The latter assumption is not necessarily shared by the models of Trabasso et al. and by Stein and Policastro. These investigators imply that both deliberate and unconscious inferencing is necessary for production and comprehension of a text.

The second class of processes includes those that are more open to manipulation by the reader. Many authors in this volume have called these processes "strategies" for interacting with text. Strategies have a heuristic and flexible character. The adoption of a strategy is influenced both by variations in the reader's purpose and by the features of a text. Strategies also allow the possibility of conscious control and are potential objectives for instruction—a set of procedures that can be taught to learners as a way of improving general reading performance.

Strategies for Subordination and Hierarchization. Several chapters in this volume suggest that one of the hallmarks of the expert reader is the ability to recognize or construct hierarchies of knowledge in which successive "layers" of subordination create a logically coherent elaboration of a topic. Bereiter and Scardamalia, Ballstaedt and Mandl, Meyer, Schnotz, and Voss develop such arguments in contrasting groups of expert (knowledgeable) and non-expert (less knowledgeable) readers. For example, Meyer's expert subjects were better able

to discriminate levels of importance of the ideas presented in the text, were more likely to focus their attention on high-importance material while reading, and showed evidence of looking for logical connective relationships rather than simply amassing details in memory. They were also more able than the non-experts to make good use of rhetorical devices that signaled which material in the text was most central to the author's argument. Similar findings are reported by Voss and Schnotz.

Scardamalia and Bereiter describe similar contrasts between younger and older readers. Younger readers tend to use a strategy in which details are emphasized in such a way that the hierarchical structure of the text is not apparent to them. Little discrimination of the relative importance among the details occurs and analysis of how specific pieces of information may support (or contradict) one another is not given by the children. A similar lack of attention to subordination structures is also noted for tasks such as scrambled sentences and writing compositions.

Generally, then, more highly skilled people tend to recognize or construct hierarchical knowledge structures as they read. They are also more likely to produce hierarchical knowledge structures when they write. This suggests another set of instructional objectives: The promotion of knowledge about the nature of various subordination relationships and of skill in using these relationships.

Self-monitoring and Questioning Strategies. Several authors propose a facilitating role for strategies by which readers monitor understanding and deliberately use their knowledge to help them understand and remember text. Two chapters report studies that assess the validity of this general proposal. Ballstaedt and Mandl's request for elaborations from readers, for example, is based on a hypothesis that when readers add their own knowledge to the information in the text, they are likely to better remember the material in the text. The hypothesis was confirmed in their study only for short-term recall; in a delayed test, the differences between subjects who elaborated aloud and those who did not had disappeared. Ballstaedt and Mandl attribute their lack of long-term effects for elaboration to subjects' in the non-elaboration group engaging in covert elaboration. But why, then, did the elaboration-aloud subjects do better in the short run?

Another possibility is that the elaboration strategy is good for studying or deliberately learning about a topic. A person who is trying to gain information from a text attempts to go beyond the text itself to a coordinated body of knowledge about the domain in question. Elaborations, especially those that establish relations between what the student already knew and what the text says, are likely to contribute to learning. Two distinct processes may be confounded if studying is equated with understanding a text. When one studies a text for purposes of learning about a domain, one is not interested in establishing or retaining a memory of the text itself or the author's particular intention. One is

interested in using the information in the text as part of a more general effort to construct a mental representation of a knowledge domain. For this purpose, it makes sense to add the text information to what one already knows and then to forget about the text *per se*. Ballstaedt and Mandl's criterion measure—recall of the text itself—may not have discriminated actual differences in learning the domain.

Brown, Palincsar, and Armbruster suggest that strategies for assessing one's state of understanding and figuring out what the author meant to say are likely to improve comprehension. Posing and attempting to answer questions is a way of meeting the goals of monitoring and finding out the author's intent. They report successful studies of direct training in question-generating strategies. Brown et al. were interested in a general skill of understanding texts rather than in comprehension of a particular text. Their criteria for success were that the strategies learned must be durable, must be applied to texts other than those on which they were trained, and that application of the strategies must improve comprehension. These criteria raise questions about the relationship between the kind of deliberate strategies taught and automated reading skill.

It is not at all clear that skilled readers regularly use the kinds of deliberate strategies taught by Brown et al. The chapters by Just and Carpenter, and by Lehnert et al., for example, present a picture of skilled performance in which processes of coherence building are largely automatic and are relatively local. Lehnert et al. find limited "ripple effects" as the result of questions. And the "immediacy" principle in Just and Carpenter's system means that the system works mainly on local coherence problems. These expert systems stay very close to the texts they are given and only rarely reorganize an already developed representation or interpretation. Nothing like posing questions about a text occurs. How can instruction that focuses on overt, self-conscious procedures for interpreting texts, and seeks to alert readers to general logical relationships rather than allowing them to attend only to local connections, improve a process that in its skilled form proceeds automatically and largely locally? The answer must lie in the fact that self-questioning strategies evoke processes of inference and interpretation that eventually evolve into the automated performances of skilled readers. This suggests, however, that metacognitive strategies may be less an aspect of reading *expertise* than of the *acquisition* of reading skill, a point to which I return in the next section.

ELEMENTS OF A COGNITIVE THEORY OF ACQUISITION

Learning, like comprehending, involves the construction of new knowledge. It is possible, therefore, to examine what is known about comprehension for elements of a theory of acquisition.

Learning As Coherence Building

Virtually all of the models of reading comprehension, formal and informal, discussed in this volume characterize reading as a process of coherence-building. That is, they describe text comprehension as resulting from a linking of new information to representations already in place or a formation of new connections between established knowledge elements. This coherence-building can be very local and immediate, a process of linking propositions in the text successively as they appear. The suggestion here for learning is that learning, too, proceeds in part by efforts to link each new piece of information to at least one other piece of information. This kind of very local coherence building is apparent in many well-studied learning tasks—for example, in memorization through the creation of mnemonics. We know that strategies of this kind enhance learning when there is a minimum of meaningful structure available. However, we are less accustomed to looking for local coherence-building efforts of this kind in the context of "meaningful" learning of organized domains of knowledge. Nevertheless, there may be more of a role for local linking processes in complex learning than has generally been assumed. Substantial amounts of new knowledge construction may proceed in small increments, without dramatic moments of "insight" or "restructuring."

Learning As Schema Instantiation and Schema Construction

A central way in which new information is interpreted and thereby appropriated by the reader is by instantiation of already established schemata. Specific events become interpretable when they provide the information needed to "fill slots" in schemata. Schema activation and instantiation are also aspects of learning. One learns about situations by interpreting them in terms of already held schemata. At the same time, the process of successive reinstantiation of schemata with new specifics enriches the schemata themselves and extends their range of applicability. Close consideration of the ways in which schema activation and instantiation works in various models of comprehension can, then, provide an important set of hypotheses about the processes of learning.

But how are the schemata called upon in learning established in the first place? If schema instantiation mechanisms, and the limited schema modification that accompanies instantiation, were the only mechanisms available for learning, we could not account for the range of people's knowledge or for their capacity for acquiring new ideas. The chapters in this volume have had little to say about the process of new schema building. Beyond a shared recognition of the importance of schema construction in learning, we have virtual theoretical silence. This remark is not intended as a criticism of the authors, but rather as a comment on the current state of cognitive theory. The chapters in this volume are by no

means alone in their silence on the issue of schema construction, indeed of the construction of declarative knowledge more generally. Piaget gave us the label accommodation to refer to this aspect of cognitive acquisition, contrasting it with assimilation (schema instantiation) in his general model of equilibration. More recently, David Rumelhart and Donald Norman have proposed that learning proceeds through three interacting processes rather than two: accretion, tuning, and restructuring. Accretion is essentially what I have called schema instantiation. Tuning and restructuring are mechanisms for the creation of new schemata, in the first case by gradual modification of existing structures, in the second by the building of brand new structures. This distinction between gradual modification of old schemata and all-in-one creation of new ones is a useful enrichment of our thinking about schema acquisition. But it is an invitation to build a theory, not an already developed theory of schema acquisition. Like Piaget, Rumelhart and Norman label the kind of learning involved, but make only general suggestions about what the actual processes of tuning and restructuring may be. Recent efforts to build formal cognitive theories of acquisition do not illuminate the question much either. These focus largely on the automation of cognitive skills and on detailed accounts of how local knowledge linkages take place. They do not really address the problem of the acquisition of new schemata. The chapters in the present volume, then, serve to highlight what is surely one of the most important current challenges for a cognitive theory of learning.

Acquiring Processing Skill

We turn next to the question of how skilled processes or procedures are learned. This is a better developed area of cognitive learning theory than is schema acquisition. The focus in most work up to now has been on how procedures become automated, and on how smooth performance is built in the course of practice. The procedural focus in the present volume, by contrast, is on conscious strategies for interacting with texts and not on automated performance. As already noted, several chapters are concerned with how people gain conscious control over their reading or writing processes. Yet implicit in this interest is a concern for the effects of strategic self-control on the automatic processes of skilled reading or writing. There are, then, two questions raised about the acquisition of processing skill. First, how are deliberate strategies acquired? Second, how do these strategies affect the acquisition of the automatic processes of skilled readers?

Acquiring Self-management Strategies. Brown, Palincsar, and Armbruster propose that deliberate processing strategies are acquired in the course of social interaction. At the beginning, another person, usually a parent or a teacher, monitors the child's state of knowledge, posing questions or prompting the child

would anticipate. Schnotz's work represents an approach to questions of text design that is explicitly concerned with adapting texts to known characteristics of people's knowledge states.

Direct Instruction—A New Meaning?

Brown et al.'s chapter indicates the possibility of directly teaching strategies and procedures that traditionally have been left up to learners to discover on their own. The authors suggest that principles of direct instruction that have proven effective for teaching limited bodies of knowledge and relatively algorithmic performances can also be applied to more heuristic kinds of skills. In the past, direct instruction has been limited to closed and predetermined bodies of knowledge and skill that could be practiced in a standard form and performed unvaryingly. Strategic and heuristic learning—the very things that distinguish between expert and novice performers in a domain—were left for people to acquire more or less on their own, or from informal commentary and criticism.

The suggestion that we directly teach heuristic skills and strategies turns out to be less simple than it seems. In particular, proposals for direct teaching of strategies raise the question of just how direct we really mean to be. As we have seen, the strategies taught are often not the ones actually used by experts. Furthermore, the strategy training methods may work only insofar as learners already have important elements of the strategies available. Strategy instruction, then, does not really work very "directly." That is, it does not directly communicate a skilled form of performance. Yet *deliberate*, if not very direct, instruction does seem to improve performance. How? Let us consider two possibilities.

One thing that instruction may do is to simply help individuals find what they already know that is relevant to the task at hand. The knowledge that is "cued" by instruction may be either procedural or declarative. Strategy teaching procedures show how procedural elements, such as the asking of questions, can be effectively called into play in the service of understanding or remembering a text. This can be done by various direct suggestions of an instructor. Questions posed by an instructor can also serve as "pointers" to declarative knowledge. In an instructional interaction that is conversational and individual, the instructor's questions and prompts can lead the student to new understanding of a domain without adding any new external "facts." In such cases, the instructor has a certain skill or body of knowledge in mind that he hopes the student will acquire. He carefully arranges patterns of interaction and/or practice that are intended to evoke that skill or knowledge. In this sense, the instruction described is "direct"—that is, intentional and instructor-led. But in another significant respect, the instruction is very indirect, for it basically only prompts the students to find and use knowledge that they already had. Nothing is directly given to the student.

A second thing that instruction may do is set the learner up to discover expert

to pose them, and directing a search for information related to the question at hand. As these "management" functions are taken over by the child, he or she becomes increasingly able to function independently. Strategic skills, then, are learned through a process of externally guided practice coupled with successive internalization of the monitoring, prompting, and evaluation aspects of the performance. A similar view is expressed by Scardamalia and Bereiter. The internalization of control theory provides a plausible account of how people learn more fruitfully to use processes already available in their repertoires. However, it does not account for how one acquires the repertoire of processes. For example, internalization alone can be expected to produce more question asking, but not necessarily to improve the quality of the questions posed. Brown et al. propose that *modeling* of high quality question asking and inferencing is the mechanism by which new repertoires are built. But they do not ask the next logical question: How does the modeling work? How do people learn from watching models perform? The modeling mechanism, then, has the same status as does accommodation, restructuring, or tuning for schema acquisition. It invites but does not provide a cognitive theory of learning.

From Self-management to Automaticity. Giving oneself directions, posing questions for oneself, and engaging in deliberate self-management strategies eventually enhance skilled performance. As we have seen, however, these activities may not themselves be implicated in skilled performance. Instead they may function as "pump primers" for setting in motion processes that will eventually function independently. Not all strategies that are useful in acquisition need be incorporated into skilled performance. I once had a piano teacher who taught me to make my playing romantic and emotional by telling me stories that evoked various emotions (loneliness, joy, despair, etc.). She asked me to play the music "so as to illustrate the events and emotions involved." As time went on, I gradually took over the storytelling as well as the piano playing role, and eventually overt storytelling was dropped. The instruction worked. I became, at least for a while, a young pianist very much in the romantic mode—a fact that was noted with varying degrees of approbation by my later music teachers. Through a process of internalization, I learned a strategy for controlling and managing the style of my piano playing. In this case it is absolutely clear that the strategy I learned, storytelling, was not itself a part of the skilled performance. I did not directly describe to myself, and therefore come to control, the actions of my fingers. My skill as a piano player nevertheless improved to a certain degree under the control of the storytelling strategy. How? That remains a mystery, a question perhaps to be answered by future research on motor skill acquisition. However, it is, I submit, no more a mystery than how Brown et al.'s subjects managed to become somewhat better comprehenders even in situations where they did not apparently consciously utilize the specific strategies they had been

taught. We must be careful to distinguish between reading skill itself and the strategies that help in acquiring that skill.

THE QUESTION OF INTERVENTION

Campione and Armbruster describe two goals of intervention research: (1) modifying the learning *materials* in order to make learning easier; and (2) modifying the learners' *processes* in order to enable them to learn from less than optimal texts. The issue of materials is raised here primarily as a question of text design, most directly in the chapter by Schnotz, but also in commentaries of Meyer, Stein and Policastro, and Trabasso, Secco, and van den Broek. The processes question is raised by Brown, Palincsar, and Armbruster, Fischer and Mandl, Scardamalia and Bereiter, and Ballstaedt and Mandl, each of whom describe efforts to evoke or teach text-processing strategies. These strategy teaching efforts raise the question of what we mean by "direct instruction" when learning is assumed to be the result of individual mental constructions by the learner.

Text Design: Implications of Cognitive Theory

One of the ways in which instructors can help people to learn is to provide them with texts that are optimally designed to highlight the most important information. There is a long history of concern for the design of teaching materials—especially textbooks—and an appreciable body of research on how to make texts more efficient tools for learning. As de Beaugrande points out, however, most past research on text design has not been based on an adequate theory of how people process texts, thereby limiting its utility. Consider the history of research on "adjunct aids" in texts—in-text questions, headings, and the like. Investigators have sought to compare the effectiveness of different kinds of adjuncts, different placements in the text, and a host of other variables; but they have been able to provide few strong and generalizable rules for when and how to use such aids. A similar point can be made by looking at the history of research on "readability." De Beaugrande documents the extent to which the question of text difficulty has been addressed independently of a theory of how people read and the difficulties that this can produce. An effort to apply theories of text processing to text design is very much needed.

Schnotz's research on optimal text organization is a welcome step in this direction. He compared two different text organizations. However, he predicted that people with different levels of prior knowledge would process the texts differently so as to benefit differently from the organizational features of the two kinds of texts. Although Schnotz's processing theory is informal, his findings demonstrate the complex interaction that a processing-based theory of text design

forms of knowledge. If knowledge construction is a pervasive aspect of learning, then we cannot insist on instructional intervention plans that present knowledge directly in its expert form. Instead, we may often want to teach a simplified version of expert knowledge that learners themselves will be able to transform into a more sophisticated skill or knowledge representation. For example, Scardamalia and Bereiter asked children to use two particular sentences as part of a story they were to compose. This posed a problem for the children, as the sentences that were given were not obviously related to one another. What eventually helped the children was a set of rather mechanical procedures: finding common words, locating synonyms, underlining phrases, and the like. These are not procedures that experts routinely use as they write. The apparent effectiveness of the teaching probably derives from the fact that the easily demonstrable procedures that were taught evoked certain processes of word meaning instantiation and semantic interpretation that could eventually proceed independently, without the support of underlining and synonym-finding algorithms. The instructors in this experiment had a clear instructional goal in mind and deliberately constructed exercises intended to promote it. In this sense their work was entirely in the spirit of direct instruction. Yet they did *not* directly teach the processes involved in creating stories. Instead, they set the children up to discover those processes.

These examples force us to a broadened definition of direct instruction, one that is in keeping with the constructive character of learning. Direct instruction is any deliberate attempt to intervene in learning so that the outcome of the learner's processes will be a particular form of knowledge or skill. Psychologists or educators interested in direct instruction should look for forms of explanation or demonstration, and forms of practice, that set in motion the learning processes which lead to expert performance. They should not seek to engage novice learners directly in performances of experts.